Claims

[c1] 1.A method for modulating the x-ray power of an imaging system so as to maintain a desired image noise in the imaging system comprising:
obtaining projection data;
correcting said projection data responsive to beam hardening errors so as to create corrected projection data;
processing said corrected projection data so as to create a plurality of emitter current values responsive to an imaging method; and
applying said emitter current values to the imaging system responsive to an object to be imaged.

[c2] 2.The method of claim 1, further comprising:
generating said projection data using an empirical method.

[c3] 3.The method of claim 1, further comprising:
operating the imaging system so as to create scout image data; and
generating said projection data responsive to said scout image data, in accordance with the equation:

$$proj_i = (scout\_image\_row - scout\_shift\_factor) / scout\_scale\_factor * normalization\_factor;$$

wherein said $proj_i$ is the projection data, said scout_image_row is a row of said scout image data and wherein said scout_scale_factor, said scout_shift_factor and said normalization factor are predetermined constants responsive to a scout reconstruction algorithm.

[c4] 4.The method of claim 1, further comprising:
correcting said projection data responsive to beam hardening errors,
wherein said projection data includes a plurality of projection data elements, in accordance with the equation:

$$proj_{bh,i} = a_{0i} + a_{1i} * proj_i + a_{2i} * proj_i^2 + a_{3i} * proj_i^3 \ldots + a_{ki} * proj_i^k \quad (i = 0, n),$$

wherein, said i represents said projection data element, said a_{0i} to said a_{ki} are coefficients responsive to a given emitter tube voltage and an imaging filter and wherein said $proj_i$ is said projection data for said projection data element.

[c5] 5.The method of claim 1, further comprising generating a projection_measure value, a projection_area value, an eccentricity value and a standard deviation prediction value.

[c6] 6.The method of claim 1, further comprising:

generating a projection_measure value, in accordance with the equation:

$$PM_i = \sum_{i=0}^{99} \{sort(proj)\}_i$$

wherein said proj is a projection data element and wherein said sort is a mathematical function for producing an array in descending order of the largest j subset of projection data elements.

[c7] 7.The method of claim 1, further comprising:

generating a projection_area value, in accordance with the equation:

$$PA = \sum_{i=0}^{887} proj_i$$

wherein, said i is the desired projection element and wherein said $proj_i$ is the i th projection data element.

[c8] 8.The method of claim 1, further comprising:

generating an eccentricity value, in accordance with the equation:

$$oval\_ratio = \frac{PM_{90,i}}{PM_{0,i}} = \frac{(PA_i - I)}{S * PM_{0,i}^2}$$

wherein, said $PM_{90,i}$ is the projection_measure for projection data element i at 90 degrees, said $PM_{0,i}$ is the projection_measure for projection data element i at 0 degrees, said PA_i is the projection_area for projection data element i, said I is an Oval_offset coefficient and said S is an oval coefficient.

[c9] 9.The method of claim 1, further comprising:

generating a standard deviation prediction value, in accordance with the equation:

$$SD_{pred} = a_0 + a_1X_1 + a_2X_2 + a_3X_1X_2 + a_4X_1^2 + a_5X_2^2$$

wherein, said X_1 = (PA * 0.001), said X_2 = oval_ratio (if oval_ratio < 1, X_2 = 1/oval_ratio) and said a_0 - a_5 are predetermined coefficients responsive to a given emitter tube voltage.

[c10] 10.The method of claim 1, wherein said processing includes determining low

emitter current value coefficients, wherein said low emitter current value coefficients optimize said emitter current values.

[c11] 11.The method of claim 1, wherein said processing includes determining an emitter current value responsive to an axial and cine imaging method, in accordance with the equation:

$$mA_{pred} = mA_{ref} * \left(\frac{SD_{pred}}{SD_{desired}}\right)^2 * \left(\frac{scantime_{ref}}{scantime_{actual}}\right) * \left(\frac{slicethickness_{ref}}{slicethickness_{actual}}\right)$$

wherein, said mA_{ref} is responsive to a baseline noise prediction, said $SD_{desired}$ is responsive to a user requested standard deviation value, said $scantime_{ref}$ is responsive to a baseline noise prediction, said $slicethickness_{ref}$ is responsive to said baseline noise prediction, said $slicethickness_{actual}$ is responsive to a user requested slice thickness, said $scantime_{actual}$ is responsive to a user requested scan time and said SD_{pred} is responsive to a predicted standard deviation value.

[c12] 12.The method of claim 1, wherein said processing includes determining an emitter current value responsive to a helical imaging method, in accordance with the equation:

$$mA_{pred} = mA_{ref} * \left(\frac{SD_{pred}}{SD_{desired}}\right)^2 * \left(\frac{scantime_{ref}}{scantime_{actual}}\right) * helical\_correction\_factor^2$$

wherein, said mA_{ref} is responsive to a baseline noise prediction, said $SD_{desired}$ is responsive to a user requested standard deviation value, said SD_{pred} is responsive to a predicted standard deviation value, said $scantime_{ref}$ is responsive to a baseline noise prediction, said $scantime_{actual}$ is responsive to a user requested scan time and said helical_correction_factor is a predetermined empirical factor responsive to the noise ratio for all helical scan methods relative to a particular helical scan method.

[c13] 13. The method of claim 10, wherein said low emitter current value coefficients are determined in accordance with the equation:

$$mA_L = mA_{pred} * (1/SDR)^2,$$

wherein, said mA_{pred} is a predicted emitter current for thick portions of said object, and wherein said SDR is a standard deviation ratio responsive to a

predicted standard deviation ratio (SDR_{pred}).

[c14] 14.The method of claim 13, wherein said low emitter current value coefficients are determined in accordance with the equation:

$$mA_L = mA_{pred}\left[1-\left(\frac{oval\_ratio-1}{\frac{c}{2}}\right)\right]$$

wherein, c is a coefficient that describes dose reduction as a function of oval ratio such that the desired image noise is increased by no more than about 5%.

[c15] 15.The method of claim 1, wherein said applying includes applying said low emitter current values in a manner responsive to a gantry angle.

[c16] 16.The method of claim 1, wherein said imaging system includes a computed tomography imaging system.

[c17] 17.A medium encoded with a machine-readable computer program code for modulating the emitter current of an imaging system so as to maintain a desired image noise in the imaging system, said medium including instructions for causing a controller to implement a method comprising:
obtaining projection data;
correcting said projection data responsive to beam hardening errors so as to create corrected projection data;
processing said corrected projection data so as to create a plurality of emitter current values responsive to an imaging method; and
applying said emitter current values to the imaging system responsive to an object to be imaged.

[c18] 18.The medium of claim 17, further comprising:
generating said projection data using an empirical method.

[c19]

19.The medium of claim 17, further comprising:
operating the imaging system so as to create scout image data; and
generating said projection data responsive to said scout image data, in accordance with the equation:

$$proj_i = (scout\_image\_row - scout\_shift\_factor) / scout\_scale\_factor * normalization\_factor;$$

wherein said proj $_i$ is the projection data, said scout_image_row is a row of said scout image data and wherein said scout_scale_factor, said scout_shift_factor and said normalization factor are predetermined constants responsive to a scout reconstruction algorithm.

[c20] 20.The medium of claim 17, further comprising:

correcting said projection data responsive to beam hardening errors, wherein said projection data includes a plurality of projection data elements, in accordance with the equation:

$$proj_{bh,i} = a_{0i} + a_{1i} * proj_i + a_{2i} * proj_i^2 + a_{3i} * proj_i^3 \ldots + a_{ki} * proj_i^k \quad (i = 0, n);$$

wherein, said i represents said projection data element, said a $_{0i}$ to said a $_{ki}$ are coefficients responsive to a given emitter tube voltage and an imaging filter and wherein said proj $_i$ is said projection data for said projection data element.

[c21] 21.The medium of claim 17, further comprising generating a projection_measure value, a projection_area value, an eccentricity value and a standard deviation prediction value.

[c22] 22.The medium of claim 17, further comprising:

generating a projection_measure value, in accordance with the equation:

$$PM_i = \sum_{i=0}^{99} \{sort(proj)\}_i$$

wherein said proj is a projection data element and wherein said sort is a mathematical function for producing an array in descending order of the largest j subset of projection data elements.

[c23] 23.The medium of claim 17, further comprising:

generating a projection_area value, in accordance with the equation:

$$PA = \sum_{i=0}^{887} proj_i$$

wherein, said i is the desired projection element and wherein said proj $_i$ is the i th projection data element.

[c24] 24.The medium of claim 17, further comprising:

generating an eccentricity value, in accordance with the equation:

$$oval\_ratio = \frac{PM_{90,i}}{PM_{0,i}} = \frac{(PA_i - I)}{S * PM_{0,i}^2}$$

wherein, said $PM_{90,i}$ is the projection_measure for projection data element i at 90 degrees, said $PM_{0,i}$ is the projection_measure for projection data element i at 0 degrees, said PA_i is the projection_area for projection data element i, said I is an Oval_offset coefficient and said S is an oval coefficient.

[c25] 25.The medium of claim 17, further comprising:

generating a standard deviation prediction value, in accordance with the equation:

$$SD_{pred} = a_0 + a_1X_1 + a_2X_2 + a_3X_1X_2 + a_4X_1^2 + a_5X_2^2$$

wherein, said X_1 = (PA * 0.001), said X_2 = oval_ratio (if oval_ratio < 1, X_2 = 1/oval_ratio) and said $a_0 - a_5$ are predetermined coefficients responsive to a given emitter tube voltage.

[c26] 26.The medium of claim 17, wherein said processing includes determining low emitter current value coefficients, wherein said low emitter current value coefficients optimize said emitter current values.

[c27] 27.The medium of claim 17, wherein said processing includes determining an emitter current value responsive to an axial and cine imaging method, in accordance with the equation:

$$mA_{pred} = mA_{ref} * \left(\frac{SD_{pred}}{SD_{desired}}\right)^2 * \left(\frac{scantime_{ref}}{scantime_{actual}}\right) * \left(\frac{slicethickness_{ref}}{slicethickness_{actual}}\right)$$

wherein, said mA_{ref} is responsive to a baseline noise prediction, said $SD_{desired}$ is responsive to a user requested standard deviation value, said $scantime_{ref}$ is responsive to a baseline noise prediction, said $slicethickness_{ref}$ is responsive to said baseline noise prediction, said $slicethickness_{actual}$ is responsive to a user requested slice thickness, said $scantime_{actual}$ is responsive to a user requested scan time and said SD_{pred} is responsive to a predicted standard deviation value.

[c28] 28.The medium of claim 27, wherein said processing includes determining an emitter current value responsive to a helical imaging method, in accordance

with the equation:

$$mA_{pred} = mA_{ref} * \left(\frac{SD_{pred}}{SD_{desired}}\right)^2 * \left(\frac{scantime_{ref}}{scantime_{actual}}\right) * helical\_correction\_factor^2$$

wherein, said mA $_{ref}$ is responsive to a baseline noise prediction, said SD $_{desired}$ is responsive to a user requested standard deviation value, said SD $_{pred}$ is responsive to a predicted standard deviation value, said scantime $_{ref}$ is responsive to a baseline noise prediction, said scantime $_{actual}$ is responsive to a user requested scan time and said helical_correction_factor is a predetermined empirical factor responsive to the noise ratio for all helical scan methods relative to a particular helical scan method.

[c29] 29.The medium of claim 26, wherein said low emitter current value coefficients are determined in accordance with the equation:

$mA_L = mA_{pred} * (1/SDR)^2;$

wherein, said mA $_{pred}$ is a predicted emitter current for thick portions of said object, and wherein said SDR is a standard deviation ratio responsive to a predicted standard deviation ratio (SDR $_{pred}$).

[c30] 30.The medium of claim 29, wherein said low emitter current value coefficients are determined in accordance with the equation:

$$mA_L = mA_{pred}\left[1-\left(\frac{oval\_ratio-1}{\frac{c}{2}}\right)\right]$$

wherein, c is a coefficient that describes dose reduction as a function of oval ratio such that the desired image noise is increased by no more than about 5%.

[c31] 31.The medium of claim 17, wherein said applying includes applying said low emitter current values in a manner responsive to a gantry angle.

[c32]

32.A method for determining an optimum emitter tube voltage for an imaging system comprising:

characterizing the imaging system so as to determine a system water-equivalent path length responsive to a relative noise increase;

determining an object water-equivalent path length;

comparing said object water-equivalent path length with said system water-equivalent path length so as to create a comparison result; and
recommending the optimum emitter tube voltage responsive to said comparison result.

[c33] 33.The method of claim 32, wherein said characterizing includes operating the imaging system so as to create pre-scan image projection data responsive to a plurality of emitter tube voltages.

[c34] 34.The method of claim 33, wherein said object water-equivalent path length is responsive to said pre-scan image projection data.

[c35] 35.The method of claim 32, wherein said characterizing includes determining said system water-equivalent path length for a plurality of emitter tube voltages, wherein said system water-equivalent path length is responsive to a pre-determined default relative noise increase.

[c36] 36.The method of claim 32, further comprising:
establishing a relationship between said object water-equivalent path length and said relative noise increase and a maximum allowed emitter tube voltage for the imaging system, wherein said maximum allowed emitter tube voltage is responsive to a known object; and
establishing a relationship between said object water-equivalent path length and the natural log of the minimum just-before-log scan data value, wherein said minimum just-before-log scan data value is responsive to said known object.

[c37] 37.The method of claim 32, further comprising:
determining said relative noise increase responsive to the emitter tube voltage;
calculating said system maximum water-equivalent path length responsive to said relative noise increase; and
calculating said object water-equivalent path length responsive to a pre-scan image projection.

[c38] 38.The method of claim 32, further comprising:
adjusting the emitter tube voltage responsive to said comparison result; and

operating the imaging system so as to generate object image data.

[c39] 39.The method of claim 38, wherein said adjusting includes adjusting emitter tube currents in a manner responsive to a weighted CT Dose Indices at different emitter tube voltages.

[c40] 40.The method of claim 38, wherein said operating includes normalizing said image noise data in a manner responsive to said emitter tube voltage.

[c41] 41.The method of claim 32, wherein said relative noise increase is selected so as to optimize the contrast to noise ratio of the imaging system.

[c42] 42.The method of claim 32, wherein said calculating includes calculating said system water-equivalent path length below which the emitter tube voltage may be used to increase the contrast to noise ratio of the imaging system.

[c43] 43.A medium encoded with a machine-readable computer program code for determining an optimum emitter tube voltage for an imaging system, said medium including instructions for causing controller to implement a method comprising:
characterizing the imaging system so as to determine a system water-equivalent path length responsive to a relative noise increase;
determining an object water-equivalent path length;
comparing said object water-equivalent path length with said system water-equivalent path length so as to create a comparison result; and
recommending the optimum emitter tube voltage responsive to said comparison result.

[c44] 44.The medium of claim 43, wherein said characterizing includes operating the imaging system so as to create pre-scan image projection data responsive to a plurality of emitter tube voltages.

[c45] 45.The medium of claim 44, wherein said object water-equivalent path length is responsive to said pre-scan image projection data.

[c46] 46.The medium of claim 43, wherein said characterizing includes determining said system water-equivalent path length for a plurality of emitter tube

voltages, wherein said system water-equivalent path length is responsive to a pre-determined default relative noise increase.

[c47] 47.The medium of claim 43, further comprising:
establishing a relationship between said object water-equivalent path length and said relative noise increase and a maximum allowed emitter tube voltage for the imaging system, wherein said maximum allowed emitter tube voltage is responsive to a known object; and
establishing a relationship between said object water-equivalent path length and the natural log of the minimum just-before-log scan data value, wherein said minimum just-before-log scan data value is responsive to said known object.

[c48] 48.The medium of claim 43, further comprising:
determining said relative noise increase responsive to the emitter tube voltage;
calculating said system maximum water-equivalent path length responsive to said relative noise increase; and
calculating said object water-equivalent path length responsive to a pre-scan image projection.

[c49] 49.The medium of claim 43, further comprising:
adjusting the emitter tube voltage responsive to said comparison result; and
operating the imaging system so as to generate object image data.

[c50] 50.The medium of claim 49, wherein said adjusting includes adjusting emitter tube currents in a manner responsive to a weighted CT Dose Indices at different emitter tube voltages.

[c51] 51.The medium of claim 49, wherein said operating includes normalizing said image noise data in a manner responsive to said emitter tube voltage.

[c52] 52.The medium of claim 43, wherein said relative noise increase is selected so as to optimize the contrast to noise ratio of the imaging system.

[c53] 53.The medium of claim 43, wherein said calculating includes calculating said system water-equivalent path length below which the emitter tube voltage may

be used to increase the contrast to noise ratio of the imaging system.

[c54] 54.A method for modulating the emitter current of an imaging system so as to maintain a desired image noise in the imaging system comprising:
obtaining an object to be scanned;
operating the imaging system so as to create image data;
displaying said image data on an output device; and
processing said image data using a processing device, wherein said processing device:
obtains projection data;
corrects said projection data responsive to beam hardening errors so as to create corrected projection data;
processes said corrected projection data so as to create a plurality of emitter current values responsive to an imaging method; and
applies said emitter current values to the imaging system responsive to an object to be imaged.

[c55] 55.A method for determining an optimum emitter tube voltage for an imaging system comprising:
obtaining an object to be scanned;
operating the imaging system so as to create image data;
displaying said image data on an output device; and
processing said image data using a processing device, wherein said processing device:
characterizes the imaging system so as to determine a system water-equivalent path length responsive to a relative noise increase;
determines an object water-equivalent path length;
compares said object water-equivalent path length with said system water-equivalent path length so as to create a comparison result; and
recommends the optimum emitter tube voltage responsive to said comparison result.

[c56]

56.A system for modulating the emitter current of an imaging system so as to maintain a desired image noise in the imaging system comprising:

a gantry having an x-ray source and a radiation detector array, wherein said gantry defines a patient cavity and wherein said x-ray source and said radiation detector array are rotatingly associated with said gantry so as to be separated by said patient cavity;
a patient support structure movingly associated with said gantry so as to allow communication with said patient cavity; and
a processing device, wherein said processing device, obtains projection data;
corrects said projection data responsive to beam hardening errors so as to create corrected projection data;
processes said corrected projection data so as to create a plurality of emitter current values responsive to an imaging method; and
applies said emitter current values to the imaging system responsive to an object to be imaged.

[c57] 57.A system for determining an optimum emitter tube voltage for an imaging system comprising:
a gantry having an x-ray source and a radiation detector array, wherein said gantry defines a patient cavity and wherein said x-ray source and said radiation detector array are rotatingly associated with said gantry so as to be separated by said patient cavity;
a patient support structure movingly associated with said gantry so as to allow communication with said patient cavity; and
a processing device, wherein said processing device, characterizes the imaging system so as to determine a system water-equivalent path length responsive to a relative noise increase;
determines an object water-equivalent path length;
compares said object water-equivalent path length with said system water-equivalent path length so as to create a comparison result; and
recommends the optimum emitter tube voltage responsive to said comparison result.

[c58] 58.A system for modulating the emitter current of an imaging system so as to maintain a desired image noise in the imaging system comprising:
an imaging system;

a patient support structure movingly associated with said imaging system so as to allow communication between said imaging system and a patient, wherein said imaging system generates image data responsive to said patient; and

a processing device, wherein said processing device, obtains projection data; corrects said projection data responsive to beam hardening errors so as to create corrected projection data;

processes said corrected projection data so as to create a plurality of emitter current values responsive to an imaging method; and

applies said emitter current values to the imaging system responsive to an object to be imaged.

[c59] 59.A system for determining an optimum emitter tube voltage for an imaging system comprising:

an imaging system;

a patient support structure movingly associated with the imaging system so as to allow communication between the imaging system and a patient, wherein the imaging system generates image data responsive to said patient; and

a processing device, wherein said processing device, characterizes the imaging system so as to determine a system water-equivalent path length responsive to a relative noise increase;

determines an object water-equivalent path length;

compares said object water-equivalent path length with said system water-equivalent path length so as to create a comparison result; and

recommends the optimum emitter tube voltage responsive to said comparison result.